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**OBSERVATIONS ON THE STRUCTURE OF SOME CORAL BEDS IN THE  
HAMILTON SHALE.**

BY BURNETT SMITH.

In the majority of the Paleozoic systems layers of rock occasionally occur which are made up in large part of the remains of corals. These coral masses in the attitudes and in the mutual crowding of their individuals, as well as in their general field relations, exhibit conclusive evidence that they lie in the position of original growth. From certainly the Silurian upward we find among such coral layers many which in structure approach, to a greater or less degree, the reefs of existing seas. Such fossil reefs are, as might be expected, more abundant in the limestones, and probably the Silurian and Devonian rocks of this type furnish us with the best examples which are to be found throughout the North American Paleozoic series.<sup>1</sup> In most cases, however, the reefs can be studied for only a small part of their extent. For instance, the Onondaga limestone of New York State is in many localities and through much of its thickness nothing more than an old reef, but here, as a rule, only a small horizontal section is exposed and the delimiting of the actual margins of the coral masses must be left to the field of conjecture. In the later Hamilton shale of the same region corals are a rather inconspicuous element when compared with the rich fauna of brachiopods and mollusks. Locally, however, we find in the shales layers which are composed of corals to the practical exclusion of other forms of life. Such layers are, in the main, of small thickness, and in studying them we are again confronted with the usual limited horizontal exposure. The coral reefs (if they can be dignified with the term) which form the basis for this description are an exception in this last respect, for they present a large and very beautiful exposure of about a mile along the eastern shore of Skaneateles Lake, in Onondaga County, New York.

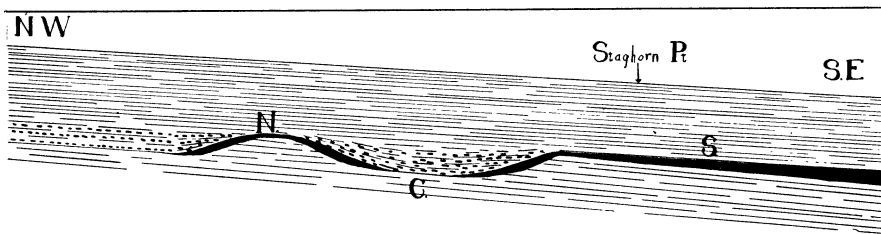
For purposes of convenience in presentation it is advisable to consider these structures under the following headings: (1) The

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<sup>1</sup> See T. C. Chamberlin, in *Geology of Wisconsin*, vol. I, 1873-79; C. J. Sarle, in *American Geologist*, November, 1901, pp. 282-299 (chiefly Bryozoa), and A. W. Grabau, in *Bull. Geol. Soc. Am.*, vol. 14, p. 337, 1903-4.

Large Southern Reef; (2) The Channel, and (3) The Small Northern Reef.

*The Large Southern Reef.*—As we follow the shore of the lake northwestward from Spafford Landing (Skaneateles Quadrangle, U. S. G. S.), the corals first appear above water level on the north side of a small point known locally under the terms Ivy Point and also Willow Point. The reef at its first appearance ranges from 3.5 feet to 4 feet thick and is made up almost entirely of the hard parts of *Zaphrentis*, *Heliophyllum*, and *Cystiphyllum*, together with the silt which filled the interstices between the growing corals and brought an end to their growth. The reef maintains this uniform character and thickness as far northwestward as the point known locally as Staghorn Point—a distance of approximately two-thirds of a mile. From Ivy Point the reef rises gradually for a ways, then runs with little or no dip well up toward Staghorn Point, where the



Diagrammatic northwest-southeast section of the Staghorn Point Coral Masses in the Hamilton Shale of Skaneateles Lake, N. Y.

Reefs in solid black. Shales in lines. Channel and reef-margin deposits in lines and dots. S = Southern Reef. C = Channel. N = Northern Reef.

dip increases. Its base is from 1 to 2 feet above high-water mark just south of Staghorn Point. Throughout this distance (from Ivy Point to Staghorn Point) the reef is apparently entirely conformable with the beds above and below. It is underlaid by thickly bedded hard limy shale, which carries a characteristic Hamilton fauna rich in brachiopods and mollusks. It is immediately overlaid by shales carrying a sparse fauna, the typical Hamilton assemblage reappearing a few feet above the reef. In the reef itself the species of brachiopods and mollusks, so abundant throughout the rest of the Hamilton, are almost entirely lacking.

Just north of Staghorn Point the base of the reef is about 5 feet above the lake level and its thickness has fallen to about 3 feet. For a distance of about 700 feet northward the reef rises until it is

finally about 8 feet above the level of the lake, while during this rise it thins rapidly down to about 9 inches in thickness. Throughout this thinning it still maintains the same conformable relations with the thickly bedded shales below and the thinly bedded shales above, as were observed south of Staghorn Point.

The reef now takes a sharp drop toward the north and thin layers of corals and limy shales fan away from it (Pl. X, Pl. XI, fig. 1). As we approach lake level the mass of corals thickens, but it is soon lost again in the complex of thin interbedded layers. We are here evidently on the northern border of the southern reef.

*The Channel.*—The space between the reef above described and that which lies to the north was evidently an open channel during most of the time when the corals of the two reefs flourished. The abrupt descent of the fanning layers from both reefs toward mid-channel and the discordance with the uniform southerly dip of the shales which later overwhelmed the reefs point conclusively to contemporaneous erosion for an explanation of the observed phenomena. This channel was gradually filled with limy silt, and occasionally an invasion of undersized corals ventured out into the currents only to be stifled by more silt without attaining maturity. These conditions are recorded by from 7 to 8 feet of thin limy shales and interbedded colonies of scattered corals. Ripple marks and cross-bedding in the limy layers bear witness to the shallowness as well as to the motion of the water in this old channel.

*The Small Northern Reef.*—At the southern edge of this small reef the conditions observed at the northern margin of the larger southern reef are duplicated. A thick mass of corals occurs near the lake level. These corals rise rapidly and during their rise from the lake the beds deposited in the old channel are seen to fan away from them. The reef rises sharply to a height of 10 feet above the lake, and here it is little more than a foot in thickness. Followed a short distance north, the conditions on the southern edge are again met with, the reef descends rapidly, thickens, and thin limy shales and coral colonies fan away from the main mass. Just north of the reef border this series of thin, ripple-marked, limy shales and seams of corals is about 9 or 10 feet thick. These beds, which owe their origin to the coral growths and to the disintegration of the corals, maintain their character for some distance along the lake shore—that is, for some distance away from the reef (Pl. XI, fig. 3), but, being reef-margin deposits, their distinctive features disappear as the distance from

the reef increases, and we can observe a gradual lateral transition into contemporaneous shale of the typical Hamilton facies.<sup>2</sup>

*Sequence of Events.*—In interpreting the observed facts we can assume with reasonable certainty that a local shallowing of the Hamilton Sea combined with an introduction of clearer water currents produced the conditions which were favorable to the growth of the corals. The limy shales were followed by communities of corals. During the growth of these beds currents kept a channel excavated in the northern portion of the region of coral growth. This channel was slowly filled with lime mud derived from the growing reefs and by invading colonies of corals, which latter, however, were never able to maintain their existence for long in the waters of the channel. Lime muds also derived from the reefs spread out for a small space around the northern margin of the area of coral growth.

When the channel between the two reefs was nearly filled with lime mud, the whole reef area was overwhelmed by fine land-derived clay muds. This effectually stopped the growth of the reefs, exterminating the corals and reintroducing the prevalent fauna of the Hamilton Seas.

#### CORRELATIONS.

As far as the author has been able to learn, the few references to the Staghorn Point coral masses which are to be found in geological literature are rather short and incidental. In view, however, of the advisability of correlating these reefs with one of the various Hamilton coral-bearing beds which occur in other portions of the county and of the State, the author believes it pertinent to mention here such references as are known to him.

In 1886 Mr. E. B. Knapp,<sup>3</sup> in a paper read before the Educational Council of Onondaga County and published at a later date, speaks of the principal collecting grounds for corals in the local Hamilton. We find also that he gives 6 feet as the thickness of the "old coral reef" at Staghorn Point.

Schneider,<sup>4</sup> in 1894, speaks very briefly of "the ancient coral reef at Staghorn Point" as an excellent collecting ground for cyathophylloid corals, but makes no mention of the size or structure of the reef.

<sup>2</sup> We have good negative evidence that the section above described is near the western limit of the coral masses, for considerable search has failed to disclose any reefs on the western shore of Skaneateles Lake.

<sup>3</sup> Knapp, E. B., *Glimpses of the Geology of Onondaga County*, p. 5.

<sup>4</sup> Schneider, P. F., *Notes on the Geology of Onondaga County*, Syracuse, 1894.

Luther,<sup>5</sup> in his *Economic Geology of Onondaga County, New York* (p. 282), says: "On the east shore, near Staghorn Point, is a very remarkable bed of fossil corals. It is a solid mass of cyathophylloid or cup corals, together with other genera. It is 5 feet thick at the thickest place, and is exposed along the shore, near the level of the water, for a distance of a quarter of a mile or more. Thousands of specimens, some of them 10 or 12 inches long, and sufficiently suggestive of staghorns to give the name to the point, are in sight in the layer or loose in the water. This coral reef, or a similar one at about the same horizon, is exposed at Lord's Hill, several miles northeast, and along the hillside west of Otisco Lake. From its position it seems probable that this bed is the eastern extension of the Encrinal band of the western counties, which abounds in cyathophylloid corals of the same species."

Cleland,<sup>6</sup> in his *Fauna of the Hamilton Formation of the Cayuga Lake Section in Central New York* (p. 85), after referring to Luther's observations, says: "Since in Ontario, Seneca, and Cayuga Counties the most abundant coral faunas are in the Basal Hamilton, either this coral reef at Skaneateles Lake is (1) a continuation of the stratum called the 'Basal Hamilton,' which is several hundred feet above the Marcellus shales in the Cayuga Lake section, or (2) the Encrinal, or (3) the union of (1) and (2), or (4) a separate stratum." Lower on the same page we find: "East of Cayuga Lake the correlation of the coral zones is yet to be worked out. However, conditions of sedimentation, such as would produce a limestone stratum anywhere in the Middle Hamilton, would be adapted to and contain what might be called a limestone fauna which would not differ materially from the fauna of the Encrinal; and whether this stratum were continuous or not, the same association of fossil would probably exist."

Leaving the interesting question of the possible equivalency of the Staghorn Point reefs with "the Encrinal" or some other of the western lime bands, let us return to the much nearer coral layers which are found to the east and northeast of Staghorn Point. Luther's locality of "Lord's Hill" I have so far been unable to identify with absolute certainty, but the exposures on the "hillside west of Otisco Lake" are numerous and probably most of them have been visited. These latter are known to exhibit an approximately northwest and southeast outcrop for about 3 miles, and as the

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<sup>5</sup> Luther, D. D., *Rep. N. Y. State Geologist*, 1895.

<sup>6</sup> Cleland, H. F., *Bull. 206, U. S. G. S.*

lower limit of the corals ranges in altitude between 1,000 feet and 1,060 feet it is reasonable to assume that the exposures trend not far from the line of strike. The coral beds of the Otisco Valley present certain differences from the Staghorn Point masses. In the first place, the coralline strata are usually thicker, probably 10 feet thick at the northernmost exposure examined, while at a ravine cutting across the north and south road which leads to the Otisco causeway<sup>7</sup> we find two beds of corals—a lower one of undetermined thickness at 1,000 feet altitude separated by non-coralline shales from an upper bed which is at least 30 feet thick. The Otisco exposures are for the most part in very narrow gullies choked with débris, and though there can be no doubt that they represent an essentially continuous system, the exact structure is hardly determinable.

The question then naturally arises as to whether or no these Otisco Valley reefs are the contemporaries and the stratigraphic equivalents of the Staghorn Point reefs. Checks with a reliable reference plane are hard to make in the Otisco Valley, but the coral masses appear to lie about 300 feet below the base of the Tully limestone, while in the Skaneateles Valley the corresponding difference is about 360 feet. Considering the great variations in thickness which these coral masses exhibit, we are, it is believed, justified in regarding this evidence as pointing to essential stratigraphic equivalency.

Regarding, then, the Otisco Valley and the Staghorn Point masses as a practically contemporaneous system of coral bodies growing in the same sea, it is advisable to notice here two other Onondaga County exposures—those near the hamlets of Vesper and Joshua (Tully Quadrangle, U. S. G. S.).

The Vesper Reef is exposed in the Fellows Falls ravine and has been mentioned very briefly by Clarke<sup>8</sup> and Luther as “exposed in the Fellows Falls ravine 3 miles west of Tully.” This bed is about 6 feet and 4 inches thick and lies approximately 350 feet below the Tully limestone or in practical agreement with the Staghorn Point reefs.

The coral layers near Joshua<sup>9</sup> lie at a much higher altitude than any of the others and their exact horizon is much less susceptible of precise determination. They are exposed between the 1,180 and

<sup>7</sup> The causeway is represented in an unfinished condition on the topographic map of the Skaneateles Quadrangle (U. S. G. S.).

<sup>8</sup> Clarke, John M., and Luther, D. D., *N. Y. State Museum Bull.* 82, p. 48.

<sup>9</sup> This is presumably Luther's “Lord's Hill” locality. See pl. 79, Lot 218, in *Sweet's New Atlas of Onondaga County*, New York, 1874.

1,300 feet contours about  $1\frac{1}{2}$  miles southeast of Joshua and some nine miles from Staghorn Point in a northeasterly direction. As this line corresponds quite closely to the general direction of dip of the Hamilton shales, the difference in altitude in no way precludes the stratigraphic equivalency of the Joshua and Staghorn Point beds. Though the horizontal exposure is very limited at the Joshua locality, we are furnished with quite an extensive vertical section. Enough is revealed to allow us to say that here we have an upper reef some 65 feet thick separated by barren shales from one or more thinner reefs.

Allowing, then, essential contemporaneity for the Onondaga County coral masses already mentioned, it is well in passing to say that other coral-bearing localities to the east of Vesper and Joshua have not yet been visited, while to the west of Staghorn Point the absence of definite reefs in the Skaneateles Valley renders Luther's suggestion of correlation with the "Encrinal band" still an open question.

*The Coral-bearing Drift of the Otisco Valley.*—Along the eastern side of the Otisco Valley exposures of the bed rock are, on the whole, quite rare. So far none of the exposures examined have shown coral beds *in situ*. The glacial drift, on the other hand, is very high in cyathophylloid corals.

The ultimate source of drift inclusions is always open to some question, but in the present case the corals, besides being specifically identical with those of the Hamilton reefs, are also of the same general size and in many cases carry adherent fragments of the Hamilton matrix.<sup>10</sup> After the examination of a large number of specimens the author believes that no reasonable doubt can exist as to the origin of these fossils.

In places the drift is so packed with corals as to preclude the theory of transportation for any considerable distance. Everything, in fact, points to a very local source, and unless we ascribe this to the Joshua reefs alone, it is believed that we are warranted in assuming the presence of extensive though drift-covered Hamilton reefs along the eastern wall of the Otisco Valley. Though the exact horizon of such hypothetical reefs must, of course, remain in doubt, the probabilities are that it coincides quite closely with the horizon of those Hamilton reefs which we can see in place.

<sup>10</sup> In view of the great number of corals in the local Onondaga limestone, and in view of the fact that the Hamilton species are also found in the limestone, it might be urged that some of this is Onondaga drift. The Hamilton reefs are, however, made up almost entirely of *Zaphrentis*, *Heliophyllum*, and *Cystiphyllum*, while the Onondaga contains not only many additional genera of corals, but an abundance of associated Brachiopods, Bryozoa, Crinoid stems, etc. These associated forms have not been found in the Otisco Valley drift.

## SUMMARY.

From the observations briefly outlined in this paper, it is believed that we can draw the following conclusions concerning the geological history of this area in central New York: (1) During Hamilton time a considerable surface of the sea-bottom shallowed, this shallowing being accompanied by the introduction of clear ocean currents with the resultant cessation or at least interruption of mud deposition.

(2) These physical changes of sea-bottom and of sea produced conditions favorable to the growth and development of the same coral fauna throughout the greater part of the area. The coral growths varied greatly in thickness with the locality. In places they endured for a considerable time, while in other nearby situations the growth was discontinuous and the history is recorded in the strata by thin interbedded coral bands and limy shales—the probable records of old channels.

(3) Though these changes, physical and faunal, were of short duration when compared with the whole of Hamilton time, they nevertheless represent perhaps the most striking episode in the history of the Hamilton Sea in this area, namely, a transitory return to Onondaga-like conditions, followed again by the mud-bearing waters and the mud-loving fauna of the typical Hamilton.

Among the unsolved problems connected with these reefs perhaps of most importance are the following:

(a) Correlation with coral-bearing horizons in the western portion of the State.

(b) Determination of the direction from which the faunal and environmental invasion came.

(c) Possible correlation with some important, though perhaps distant, crustal movement.

Acknowledgments are due to Mr. Sedgwick Smith, of Harvard University, for assistance in the field, and to Mrs. Ethel Ostrander Smith, who photographed the reef structures under rather difficult conditions.

## EXPLANATION OF PLATES X AND XI.

PLATE X.—Coral layers fanning away from the northern margin of the Southern Reef (see text figure, S) near Staghorn Point, Skaneateles Lake, N. Y. Eroded shale (*a*) below, followed by fan or wedge-shaped reef-margin deposits (*b*), with thinly bedded shale (*c*) at the top.

PLATE XI.—Reef and reef-margin deposits near Staghorn Point, Skaneateles Lake, N. Y.

Fig. 1.—Coral layers fanning away from the northern margin of the Southern

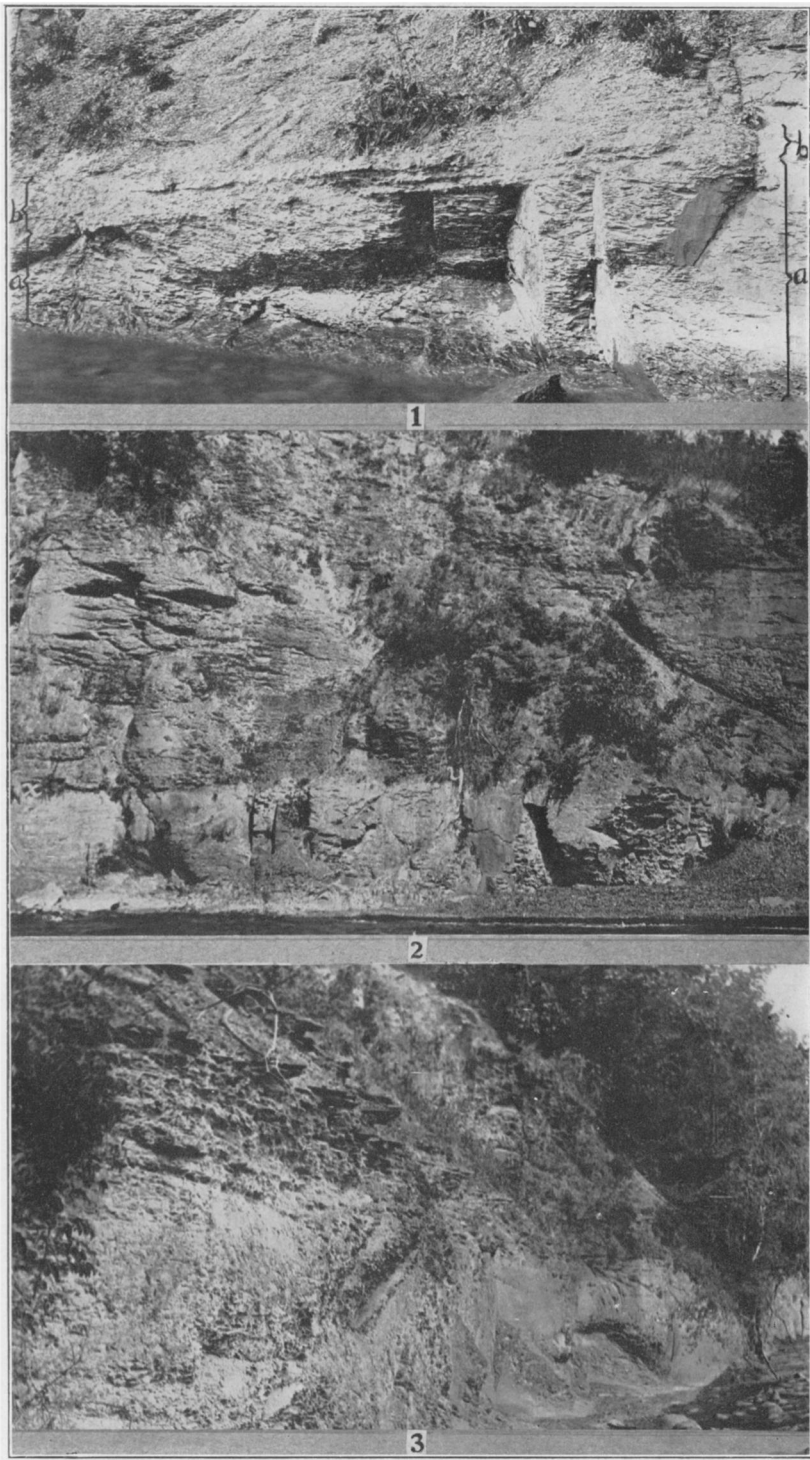
Reef (text figure, S). Illustrates the abrupt northward (to the left) descent of the marginal deposits (*b*) into the channel (see text figure, C) and the truncation of the southward dipping shale (*a*) below.

Fig. 2.—Northern margin of the Southern Reef. In this figure the reef itself cannot be distinguished, but its base is shown by the top of the truncated shale below the reef. The discordance between the line of truncation (*x, y*) and the southward dip of the shale above the reef is also illustrated.

Fig. 3.—Reef-margin deposits about the northern border of the Northern Reef (see text figure, N). These deposits lie beyond the area in which fanning occurs and their alternating hard and soft layers are essentially parallel. The hard layers are limy and the soft layers are friable shale.



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